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Institution: University of California, San Diego

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Project Progress

Most recent report of results to date:

Greenhouse warming of the ocean

One source of low-frequency predictability in the ocean is the near-monontonically increasing anthropogenic forcing. We have gone further into analyzing the ocean's response to this forcing than has been done before. On a basin scale, numerical models forced with estimated emissions of CO2 and sulfate aerosols over the historical era (1950-1999) show excellent agreement with the observations in the strength and vertical profile of ocean warming. One particularly interesting result to come out of this is that local variations in net surface heat flux can be important to determining a basin's warming, as can changes in the basin-wide circulation. The Pacific Ocean is the best example of this; it is the only ocean to show a significant layer (centered ~400 m depth) with long term cooling, which appears to be a reflection of the redistribution of warm water due to changes in circulation. One of the anthropogenically forced model ensembles captured this behavior. We are proceeding to analyze this case in detail to see what implications it might have for long term changes in the tropical Pacific, which affects such important phenomena as ENSO and the Indonesian throughflow.

Western U.S. hydrologic variations

Recent work by Cayan has contributed to further investigations of the impact of recent decades' warming in western North America on hydrologic variations over this region. In a recent paper (Knowles et al., 2005 submitted to J. of Climate), changes in the precipitation regime toward more rain and less snow over the western conterminous United States has been documented. Such changes are of interest because the water resources of the western U.S. depend heavily on snowpack to store part of wintertime precipitation into the drier spring and summer months, and because changes in the last few decade may be an early symptom of climate warming. A well-documented shift towards earlier runoff in recent decades has been attributed to 1) more precipitation

falling as rain instead of snow, and 2) earlier/faster snowmelt. The present study addresses the former, documenting a regional trend during the period 1949-2004 toward smaller ratios of winter-total snowfall water equivalent (SFE) to winter-total precipitation (P). The most pronounced reductions in this ratio have occurred in the Sierra Nevada and the Pacific Northwest, with more varied changes (but still predominantly reductions) in the Rocky Mountains. Trends in this ratio correspond to shifts toward less SFE rather than to changes in total precipitation, except in the Southern Rockies where both snowfall and precipitation have increased.

Indonesian Throughflow (Potemra and Schneider 2005, see below)

Results from a 300-year integration of the NCAR PCM coupled model are used to examine the impact of low-frequency (periods between 36 and 120 months) Indonesian throughflow (ITF) transport on Indian Ocean temperatures. Using correlation and regression analysis, we show that the co-variations of anomalies of model Indian Ocean temperature and ITF transport largely reflect concurrent atmospheric forcing, rather than oceanic adjustment to changes of the throughflow. The low-frequency variations in ITF transport are of the order of 1 Sv, and have a minimal impact on surface temperatures. The impact on thermocline level temperatures is greater, but in this model it is limited to the outflow region between Java and Australia extending westward along a band between 10S and 15S.

The Pacific Decadal Oscillation in a coupled model

The dynamic similarity of Pacific Decadal Oscillation in observations and an extended control integration of the coupled climate model PCM is investigated. In accordance to our recent analysis of observations (Schneider and Cornuelle 2005, see below), the PDO in the coupled model results from a superposition of forcing by the Aleutian low, and by atmospheric and oceanic teleconnections from the tropics, and ocean circulation anomalies in the Kuroshio-Oyashio Extension. The former two forcings affect the upper ocean heat budget directly throughout the North Pacific, and then lead via a delayed response of the mid-latitude ocean gyre to surface temperature anomalies the KOE. However, in the model, the surface variations results primarily from changes of the thermocline depth, rather than from meridional advection, as in observations. The differences between observer and modeled pattern of the PDO, of the forcing footprints, and of the processes in the KOE reflect shortcomings of the mean state of the simulated SST and weak mean circulation.

Analysis of decadal changes in the tropics in the PCM

Work is underway to describe the decadal modulation of the tropical Pacific and ENSO in an extended control simulation of the PCM model. From the model output we have calculated indices for thermocline depth, thermocline sharpness, spiciness and transport of the subtropical cell. In latitude bins, the output of the coupled model was converted to isopycnal coordinates, and the in volume of water, its temperature and its meridional velocity and transport in density classes was calculated. We are now in the process of

investigating the resulting time series, and relating their variations to low frequency changes of tropical SST and the modulation of the model ENSO.

Regional ocean impacts of global warming

Heating by surface heat fluxes was found by Di Lorenzo et al. (2005) to shut down the coastal upwelling cell in spite of an increase in upwelling favorable winds observed since the 1976-77 climate shift. This offers a concrete physical explanation for the observed decline in zooplankton since the 1976-77 climate shift. The model also reveals that mesoscale eddy variance increased after the shift. This is another mechanism that can have a profound impact on biological productivity in the region. This same model is being used by us to predict the changes in coastal circulation in 2050 using the winds from a greenhouse-gas forced global simulation of PCM. These results are now being analyzed for their effect on the ocean productivity, as an enhancement to the results of Pierce (2004a), which do not resolve the eastern boundary current dynamics

Most recent products delivered:

Barnett, T. P., Pierce, D. W., AchutaRao, K. M., Gleckler, P. J., Santer, B. D., Gregory, J. M., and Washington, W. M., 2005: Penetration of human-induced warming into the world's oceans. Science, doi:10.1126/science.1112418.

Di Lorenzo, E., A. J. Miller, N. Schneider and J. C. McWilliams, 2005: The warming of the California Current: Dynamics and ecosystem implications. J. Phys. Oceanogr., 35, 336-362.

Huang, B., V. Mehta and N. Schneider, 2005: Oceanic response to idealized net atmospheric freshwater in the Pacific at decadal timescale. J. Phys. Oceanogr., accepted.

Knowles, N., Dettinger, M. D., and D.R. Cayan, 2005: Trends in Snowfall versus Rainfall for the Western United States, 1949-2004 submitted to J. Climate.

Mestas-Nunez, A. M. and A. J. Miller, 2005: Interdecadal variability and climate change in the Eastern Tropical Pacific: A review. Progress in Oceanography, in press.

Miller, A. J., A. J. Gabric, J. R. Moisan, F. Chai, D. J. Neilson, D. W. Pierce, and E. Di Lorenzo, 2005: Global change and oceanic primary productivity: Effects of ocean-atmosphere-biological feedbacks. Global Climate Change and Response of the Carbon Cycle in the Equatorial Pacific and Indian Oceans and Adjacent Land Masses, Elsevier Oceanography Series, sub judice.

Miller, A. J., E. Di Lorenzo, D. J. Neilson, H.-J. Kim, A. Capotondi, M. A. Alexander, S. J. Bograd, F. B. Schwing, R. Mendelssohn, K. Hedstrom and D. L. Musgrave, 2005: Interdecadal changes in mesoscale eddy variance in the Gulf of Alaska circulation: Possible implications for the Steller sea lion decline. Atmosphere-Ocean, in press.

Pierce, D. W., Barnett, T. P., AchutaRao, K. M., Gleckler, P. J., Gregory, J. M., and Washington, W. M., 2005: Anthropogenic warming of the oceans: observations and model results. Submitted to J. Climate.

Potemra, J. T. and N. Schneider, 2005: Influence of low-frequency Indonesian Throughflow tranport on temperatures in the Indian Ocean in a coupled model. J. Climate, submitted.

Schneider, N. and B. D. Cornuelle, 2005: The forcing of the Pacific Decadal Oscillation. J. Climate, accepted.

Schneider, N., E. Di Lorenzo and P. P. Niiler, 2005: Salinity variations in the Southern California Current. J. Phys. Oceanogr., accepted.

Most recent notes concerning the project:

None

Other Project Information Sources:

Project URL:

None

Related URL at institution:

None

Note: This project was renewed under DOE award # DE-FG02-01-ER63857